A New Grading System for Evaluation of Technical Difficulty of Aneurysm Treatments

Presentation of the System and a Four Year Experience of Its Application to Ruptured Aneurysms

S. OTA[1], TO. OTA[2], T. FUKUSHIMA[3], S. SATO[4], TA. OTA[5], K. GOTO[6]

[1] *Department of Neurosurgery, Brain Attack Center Oota Memorial Hospital, Fukuyama, Hiroshima, Japan*
[2] *Department of Cardiology, Brain Attack Center Oota Memorial Hospital, Fukuyama, Hiroshima, Japan*
[3] *Fukuyama Transporting Shibuya Longevity Health Foundation, Fukuyama, Hiroshima, Japan*
[4] *Department of Neurosurgery, Brain Attack Center Oota Memorial Hospital, and currently working for Sato Neurosurgery Clinic, Fukuyama, Hiroshima, Japan*
[5] *Department of Neurosurgery, Brain Attack Center Oota Memorial Hospital, Fukuyama, Hiroshima, Japan*
[6] *Department of Neuroradiology, Brain Attack Center Oota Memorial Hospital, Fukuyama, Hiroshima, Japan*

Key words: cerebral aneurysms, coil embolization, neck clipping, subarachnoid hemorrhage, ISAT

Summary

We introduced our grading system that enables us to objectively evaluate the degree of technical difficulty of aneurysm treatment modalities, i.e. neck clipping and coil embolization. The characteristics of our grading system were that the difficulty of each treatment was indicated on a ten point scale obtained by adding the scores for various technical factors. We studied annual change of treatments selected for ruptured aneurysms and the treatment results at our institute. In the earlier half of the study period, neck clipping was more frequently selected despite the fact that the difficulty score of coil embolization was lower than that of neck clipping. However, in the later half, the treatment modality was selected in accordance with the difficulty score in most of the cases. As a result, there was a tendency for the proportion of mRS 0 to increase and that of mRS 6 to decrease as the years passed. Our grading system may be useful in objectively selecting a more appropriate treatment, and further improve treatment results.

Introduction

With the improvement of materials and technique, more and more aneurysm cases tend to be subjected to endovascular treatment. The result of the ISAT study[4,5] greatly prompted this tendency by revealing less invasiveness of coil embolization compared with neck clipping at least for ruptured aneurysms with mild to moderate subarachnoid hemorrhage (SAH). However, selection of treatment modality for cerebral aneurysms still differs widely from country to country and from institute to institute.

According to the latest nationwide questionnaire survey conducted by one of the major Japanese newspaper companies, approximately 80% of aneurysms were clipped in the year 2006. Also it was revealed that selection of the treatment modality was performed rather arbitrarily and the stronger treatments are recommended in many hospitals[3].

We strongly feel a need to establish a way to objectively select a more appropriate treatment for each case in order to perform fair informed consent and further improve treatment results.

The purpose of this article is to introduce our grading system that enables us to objectively evaluate the degree of technical difficulty of each treatment modality, to study annual change in the proportion of treatments selected for ruptured aneurysms and the treatment results for four years at our institute.

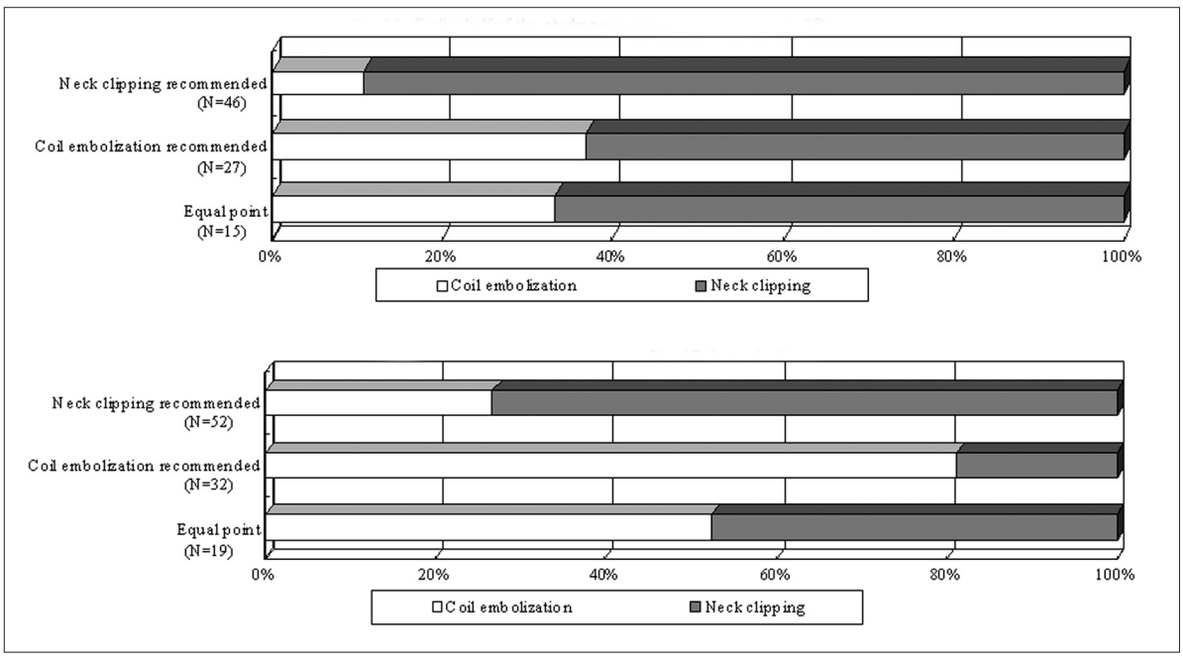

Figure 1 Relationship between the recommended procedures based upon our grading system and the actual selection of the procedures. Comparison between the earlier (A) and the latter half (B) of the study period.

Materials and Methods

Case Materials

We studied 282 consecutive patients with ruptured aneurysms treated at our hospital from June 2002 to December 2005. Baseline characteristics of our patients are shown in table 1. One hundred and twenty-one patients (42.9%) underwent neck clipping, 70 patients (24.8%) underwent coil embolization, and the other 91 (32.3%) patients received non-surgical (medical) treatments. Patients with the following conditions were excluded from curative treatments: critical physical condition, very advanced age, severe dementia and angiographically unidentifiable source of hemorrhage.

Table 1 **Baseline characteristics of our patients.**

	Neck Clipping (N=121)	Coil Embolization (N=70)
Male	42 (34.7%	33 (47.1%)
Age (years), mean ± SD (median, range)	61 ± 10 (60, 37-81	63 ± 15 (64, 13-87)
WFNS grade		
1	62 (51.2%)	30 (42.9%)
2	23 (19.0%)	10 (14.3%)
3	6 (5.0%)	2 (2.9%)
4	15 (12.4%)	9 (12.9%)
5	15 (12.4%)	19 (27.1%)
Maximum diameter of the Aneurysms (mm)		
- 10	116 (95.9%)	62 (88.6%)
11-24	5 (4.1%)	8 (11.4%)
25 -	0	0

WFNS: World Federation of Neurological Surgeons clinical grading scale

Methods

Selection of curative treatments, i.e. neck clipping or coil embolization, was performed with reference to our grading system. An annual change in 1) ratio of coil embolization to neck clipping, 2) severity of SAH on admission (World Federation of Neurological Surgeons (WFNS) clinical grading scale) [1], and 3) modified Rankin Scale (mRS) on discharge was evaluated retrospectively. Details of our grading system are described below.

Our Grading System

Our grading system devised to assess the difficulty of neck clipping is shown in table 2. Two main technical factors, namely surgical approach and clipping, were evaluated. For surgi-

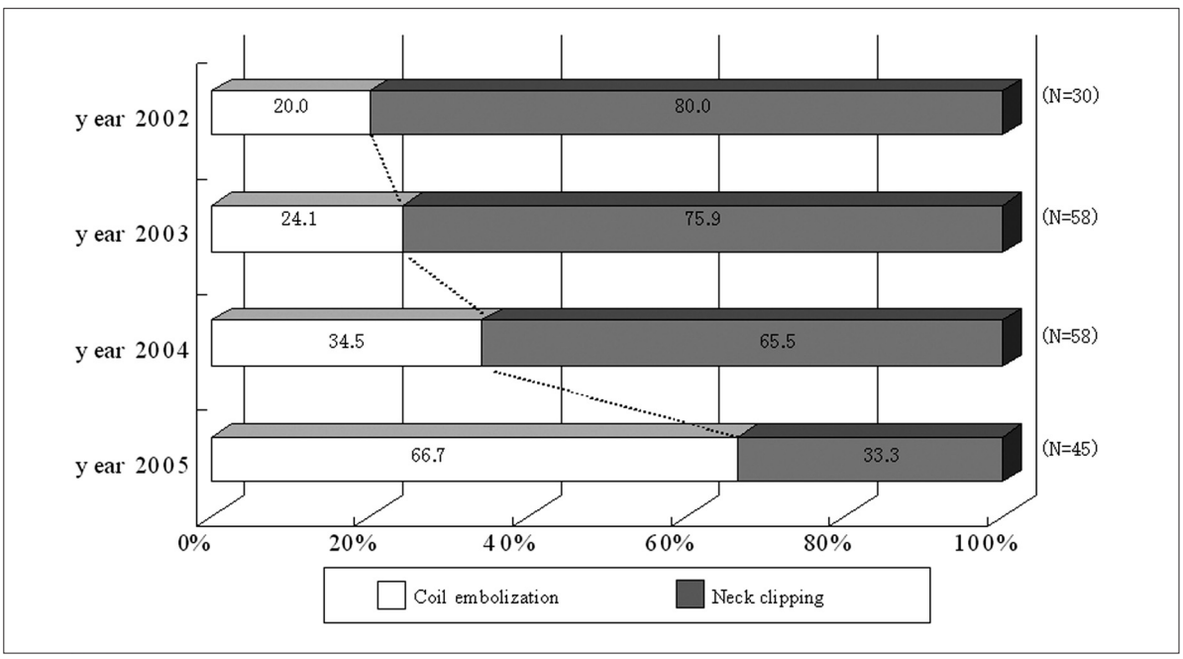

Figure 2 Annual change in the ratio between coil embolization and neck clipping.

cal approach, location of the aneurysm, existence of cranial nerves in the vicinity of the aneurysm and timing of surgery were evaluated. For clipping, the size of the aneurysm and existence of perforating arteries around the aneurysm were evaluated. These specific features were weighted from 0 to 2 according to the difficulty experienced during clipping procedure of unruptured aneurysms ending up in various complications of surgery.

Our grading system devised to assess difficulty of coil embolization is shown in table 3.

Table 2 **Grading system for assessing difficulty of neck clipping.**

point		0	1	2
Surgical Approach	Location	MCA IC-PC	Acom, MCA-LSA VA-PICA IC-bifr IC-AchoA Distal ACA	High Acom paraclinoid BA-top BA-SCA PCA VA dissection
	Cranial Nerve		II, III	VII, VIII, IX
	Timing of Treatment	Unruptured	Chronic	Acute
Clipping	Size (mm)	36	7-15 -2	16-
	Perforating Artery		LSA, MSA AchoA	TPA

MCA: middle cerebral artery, IC: internal carotid artery, PC: posterior communicating artery, Acom: anterior communicating artery, LSA: lenticulostriate artery, VA: vertebral artery, PICA: posterior inferior cerebellar artery, bifr: bifurcation, AchoA: anterior choroidal artery, ACA: anterior cerebral artery, BA: basilar artery, SCA: superior cerebellar artery, PCA: posterior cerebral artery, MSA: medial striate artery including recurrent artery of Heubner, TPA: thalamo perforating artery

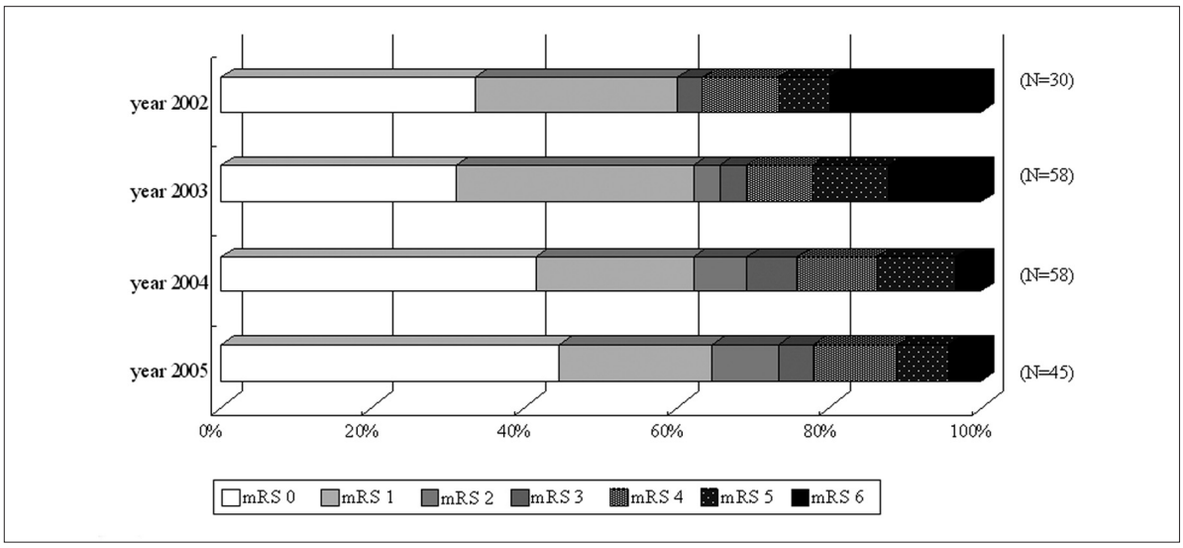

Figure 3 mRS on discharge for the entire patient population treated by either neck clipping or coil embolization.

Two main technical factors, namely the endovascular approach and coil placement, were evaluated. For the endovascular approach, location of the aneurysm, tortuosity of the parent artery and the angle between the long axis of the aneurysm and the parent artery were evaluated. For coil placement, the shape of the aneurysm, dome/neck ratio, size of the aneurysm and timing of treatment were evaluated. These specific features were weighted from 0 to 2 according to the difficulty experienced during coil embolization procedures on complex aneurysms.

Selection of technical factors and their weighting for clipping were performed by the authors S.O. and S.S. They are board certified neurosurgeons having an experience of clipping more than 470 aneurysms with less than 3% permanent technical complication rate. Selection of technical factors and their weighting for coiling were performed by the authors S.O. and K.G. who are board certified neuro-en-

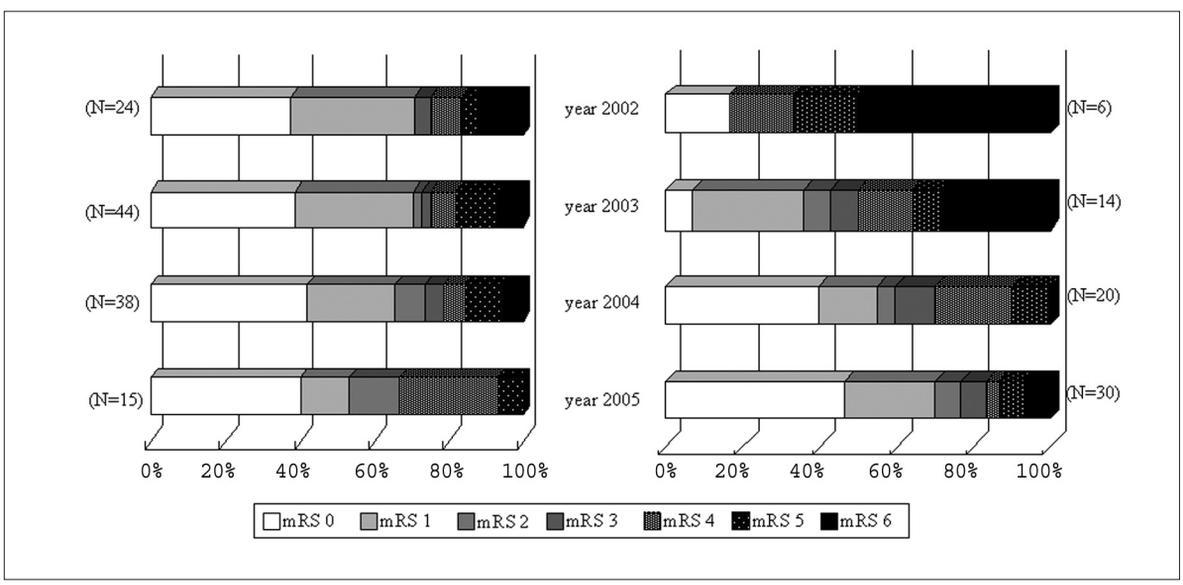

Figure 4 mRS on discharge for the NC group (A) and CE group (B).

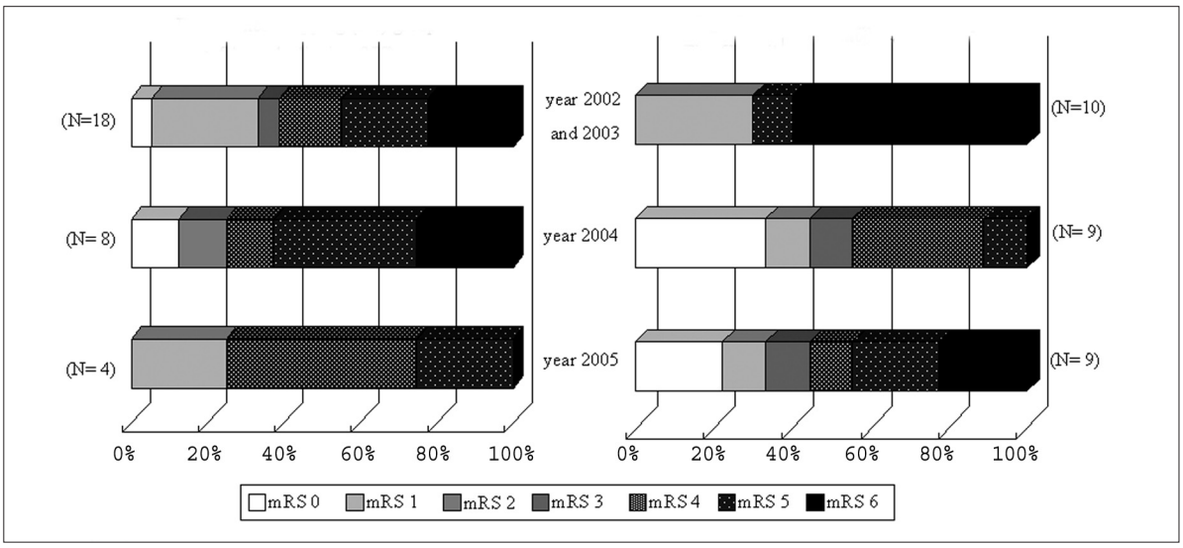

Figure 5 mRS on discharge of patients with severe SAH (IV<=WFNS (N=58).

dovascular therapists having an experience of embolizing more than 400 aneurysms using detachable coils with less than 3% permanent technical complication rate. Fine tuning of the grading system was performed before starting the study by checking whether the sum of the scores of coiling and clipping became equal for ten cases treatable by either technique with the same degree of difficulty. This was performed by one of the authors (S.O.) who is engaged in both clipping and coiling on a daily basis.

The sum of these scores was used to evaluate the difficulty of the procedure. If the scores for clipping and coiling were equal, the patient's choice was respected most.

Statistical Analyses

Continuous variables were expressed as means ± 1 SD. To determine the normal distribution of variables, we used the Shapiro-Wilk test. According to this result, the Mann-Whitney U-test was used for nonparametric com-

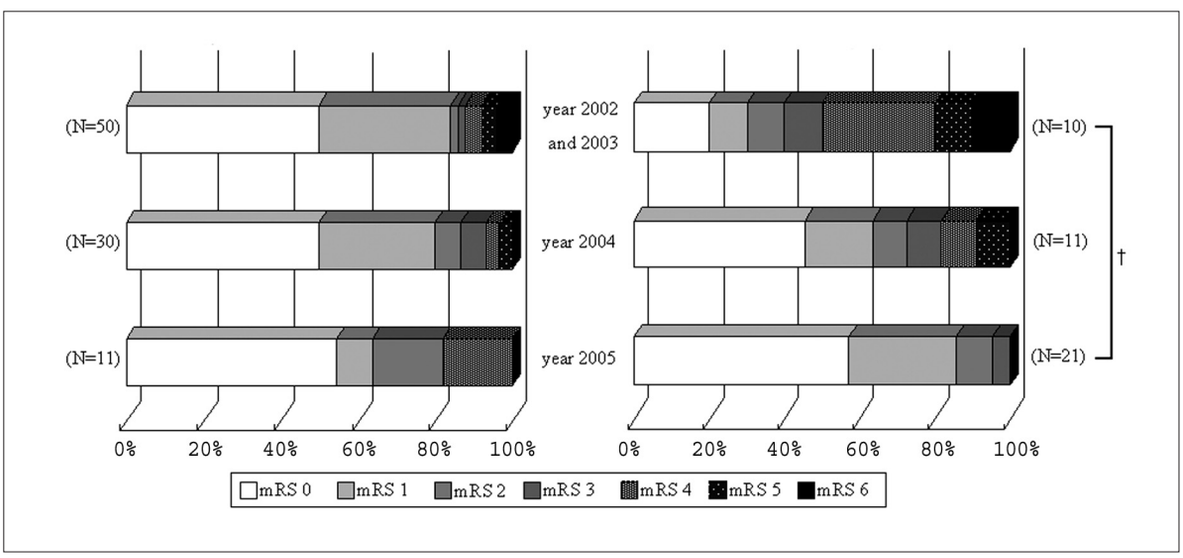

Figure 6 mRS on discharge of patients with mild to moderate SAH (WFNS<=III (N=133). † P<0.05 by chi-square test for mRS 0 to1 in the CE group.

Table 3 **Grading system for assessing difficulty of coil embolization.**

point		0	1	2
Surgical Approach	Location	prozimal (IC, VA, BA)	distal (MCA-ACA, PCA)	peripery M2-,A2-,P3-)
	Tortuosity	mild	severe	
	Angulation	< 45 degree	> 45 degree	
Coil placement	Shape	spherical	irregular	
	dome/neck ratio	> 1.5 and Neck >=5 mm	1.0-1.5 or Neck >=5 mm	<=1.0 or Branch from dome
	Size (mm)	4-8	9-15	-3 16-
	Timing of treatment	unruptured chronic	acute	

IC: internal carotid artery, VA: vertebral artery, BA: basilar artery, MCA: middle cerebral artery, ACA: anterior cerebral artery, PCA: posterior cerebral artery, M2: M2 segment of middle cerebral artery, A2: A2 segment of anterior cerebral artery, P3: P3 segment of posterior cerebral artery

parison. Differences between the groups in the categorical variable were analyzed by the chi-square test or Fisher's exact test. A P value of less than 0.05 was considered to indicate statistical significance.

Results

Patients' Demography and Selection of Treatment Modality

Age, sex, lengths of hospital stay, and WFNS grade on admission were compared between the neck clipping (NC) and the coil embolization (CE) groups annually (table 4).

As the years went by, there seemed to be a progressive decrease in the length of hospital stay and WFNS grade on admission in the coil embolization group.

The difference in the length of hospital stay was statistically significant in the year 2005 between the two groups ($P<0.05$).

The same could be said for that of WFNS grade in the year 2002 ($P<0.05$). There was no annual change in the WFNS grade in the entire group (NC + CE). The relationship between the grading scores and the actual selection of the treatment modality are noted mentioned in figure 1.

Table 4 **Annual change of demography. Neck clipping (NC) group vs. coil embolization (CE) group. Mean ± SD /median) or No. (%), Mann-Whitney test or chi-square test for NC vs. CE, annually † P <0.05.**

		2002 (N=30)	2003 (N=58)	2004 (N=58)	2005 (N=45)
Age	NC	61 ± 10 (58)	60 ± 11 (62)	60 ± 9 (59.5)	61 ± 12 (63)
	CE	65 ± 13 (66)	69 ± 16 (75.5)†	66 ± 12 (64)	59 ± 16 (58)
Male	NC	10 (41.7)	16 (36.4)	12 (31.6)	4 (26.7)
	CE	3 (50.0)	5 (35.7)	7 (35.0)	17 (56.7)
Stay in hospital (days)	NC	42 ± 24 (37)	51 ± 48 (35)	44 ± 26 (34)	55 ± 28 (46)
	CE	56 ± 45 (57.5)	47 ± 29 (38.5)	45 ± 28 (32.5)	39 ± 41 (24.5)†
WFNS on admission	NC	2.1 ± 1.5 (1)	2.2 ± 1.5 (1)	2.2 ± 2.0 (2)	2.2 ± 1.6 (1)
	CE	3.7 ± 1.8 (4.5)†	3.0 ± 1.6 (2.5)	2.8 ± 1.8 (2.5)	2.2 ± 1.7 (1)
	NC + CE	2.4 ± 1.6 (2)	2.4 ± 1.6 (2)	2.4 ± 1.6 (2)	2.2 ± 1.6 (1)

Comparison was made between the earlier (figure 1A) and the latter half (figure 1B) of the study period. In the earlier half of the study period, neck clipping was more frequently selected despite the fact that the difficulty score of coil embolization was lower than that of neck clipping. However, in the latter half of the study period, the treatment modality was selected in accordance with the difficulty scores in most of the cases.

The ratios of treatments selected, i.e. coil embolization vs. neck clipping, are shown annually in figure 2. The graph shows a marked increase in coil embolization as the years went by, and about 65% of the cases with ruptured aneurysm were treated by coil embolization in the year 2005.

Treatment Results

Figure 3 showed the annual change in the proportion of mRS at discharge for the entire patient population. It was obvious that there was a tendency for the proportion of mRS 0 to increase and that of mRS 6 to decrease as the years passed. Further analyses were performed by dividing patients into two groups: neck clipping and coil embolization groups (figure 4). Though there was no change in the proportion of mRS in the neck clipping group, there was a marked increase in patients with mRS 0 to 1 in the coil embolization group as the years passed. Concerning mRS at discharge of patients with severe SAH (figure 5), there had been no annual change both in the neck clipping and the coil embolization groups. When analyses were performed on cases with milder SAH (figure 6), the proportion of the cases with mRS 0 to 1 had significantly increased in the coil embolization group as the years passed. This phenomenon was not observed in the neck clipping group. The treatment results of coil embolization in patients with WFNS 0 to 3 in 2002-2003 appear to be worse than those of neck clipping.

This may be attributed to the difference in the mean age between the neck clipping and coil embolization groups: 58 years old in the neck clipping and 71 years old in the coil embolization groups.

Follow-Up Results

Follow-up study was performed using MRIs and plain skull films every six months after the procedure. As eight patients in the neck clipping group and nine patients in the coil embolization group were dead at the time of discharge, 113 patients in the neck clipping group and 61 patients in the coil embolization group were followed. During one year follow-up, there were no cases in the neck clipping group and one case (1.6%) in coil embolization group that needed re-treatment. The incidence of rebleeding during one year follow-up was zero in both groups.

Discussion

Neck clipping has been regarded as the gold standard for the treatment of cerebral aneurysms for many years. However, there has been a marvellous progress of materials and techniques of coil embolization for the last decade, and more and more aneurysm cases tend to be subjected to endovascular treatment. The result of the ISAT study published in 2002 [4,5] greatly prompted this tendency by revealing less invasiveness of coil embolization compared with neck clipping at least for ruptured aneurysms with mild to moderate SAH. However, selection of treatment for cerebral aneurysms still greatly differs from country to country and from institute to institute.

Recently, one of the major Japanese newspaper companies performed a nationwide questionnaire survey for 356 neurosurgery departments where treatment of more than 50 aneurysms was performed annually or where neuroendovascular services are available [3].

According to the response obtained from 313 departments (response rate 88%), approximately 80% of aneurysms were clipped in the year 2006. Also it was pointed out that selection of the treatment modality had been performed rather arbitrarily and the stronger treatment had been recommended in many hospitals.

In our country, most cases with SAH are admitted directly to the neurosurgical domain where neuro-endovascular therapists are an absolute minority (6316 board certified neurosurgeons vs. 385 board certified neuro-endovascular therapists in the year 2006). In order to perform a fair informed consent and further improve treatment results, we strongly felt a need to establish a way to objectively select a more appropriate treatment for each case.

The characteristics of our grading system were that the difficulty of each treatment was

indicated on a ten point scale obtained by adding the scores for various technical factors.

Surgical approach and neck clipping were the two main factors affecting the difficulty of the surgical procedure (table 2). As decisive factors for the difficulty of a surgical approach, location of the aneurysm, existence of cranial nerves in the vicinity of the aneurysm, and the time lapsed after the onset of SAH were picked up. As decisive factors for the difficulty of clipping, the size of the aneurysm and existence of a perforating artery around the aneurysm were evaluated.

Aneurysms in the anterior circulation were easier to approach while aneurysms with cranial nerves or perforating arteries in their vicinity were more difficult to approach. Too large or too small aneurysms were more difficult to clip than medium sized ones.

The difficulty of endovascular approach and that of coil placement were the two main factors deciding the difficulty of coil embolization (table 3). As for microcatheter placement, the location of the aneurysm, tortuosity of the parent artery, and the angle between the parent artery and the long axis of the aneurysm were evaluated. As for the difficulty of coil placement, the shape of the aneurysm, dome/neck ratio, size of the aneurysm and the time lapsed after the onset of SAH were evaluated. Microcatheter placement to aneurysms was easier if the lesion was located in the proximal region and on a less tortuous blood vessel. It was more difficult if the angle between the parent artery and the log-axis of the aneurysm was larger. Also, coil placement to the aneurysm with a wide neck was more difficult. Too large or too small aneurysms were more difficult to coil than medium sized ones.

Points for these evaluation items are added to obtain the difficulty score for each treatment modality on a ten point scale, and patients were advised to take a treatment with lower score. If the scores for both treatments were equivalent, the patient's choice was respected most.

Since the publication of the ISAT study results and increase in expertise in our endovascular team, there has been considerable increase in the ratio of endovascular treatment annually. Figure 3 shows the treatment results of the entire patient population. It seemed to have improved year by year, although no statistical significance has been found because the number is too small.

Figure 6 compares the results between the different treatment modalities. It showed considerable improvement in the coil embolization group in mild to moderate SAH patients with WFNS 0 to 3.

This was statistically significant, regardless of the small number for comparison.

What are the factors influencing treatment outcome? We believe that, in addition to the improvement in endovascular treatment devices and physician skills, selection of treatment modality was more appropriately performed in the latter half of the study period based upon our grading system. In the earlier half of the study period, many patients went to surgical clipping despite the fact that the score for coiling was lower. Concerning this, it should be noted that no significant change in the mean severity of SAH before treatment was observed over the years (table 4).

As was said in the ISAT study, the unsolved problem of coil embolization is the lack of results of long-term follow-up[2,6]. Incomplete aneurysm obliteration may influence the prognosis, because remnant growth of the aneurysm may end up in recanalization and rebleeding. Longer-term follow-up on a larger cohort of patients is required to establish which treatment modality is best suited for ruptured aneurysms.

One of the limitations of this study is also related to short observation. Nevertheless, we dare say that short-term prognosis is also important because SAH itself has a poor prognosis. If we depend too heavily on clipping, the incidence of complications related to surgery will increase. If we depend too heavily on coil embolization, we might end up in inviting rebleeding by recanalization of the aneurysm. For more objective selection of appropriate treatment modalities for ruptured aneurysms, our grading system may be useful.

Neurosurgeons say clipping is everything. Interventionists say coiling is everything. We say everything is relative.

Conclusions

Our grading system enables us to evaluate objectively the degree of technical difficulty of neck clipping and coil embolization for ruptured cerebral aneurysms and it may bring better treatment results.

References

1 Drake CG: Report of World Federation of Neurological Surgeons Committee on a Universal Subarachnoid Hemorrhage Grading Scale. J Neurosurg 36: 985-986, 1988.
2 Feigin VL, Findlay M: Advances in subarachnoid hemorrhage. Stroke 37: 305-308, 2006.
3 Tonegawa M: Treatment results for intracranial aneurysms in major institutes in 2006 [in Japanese]. The Yomiuri Shinbun, Jun 10, 14, 2007.
4 Molyneux A, Kerr R, Stratton I et Al: International Subarachnoid Aneurysm Trial (ISAT) Collaborative Group: International Subarachnoid Aneurysm Trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms: A randomized trial. Lancet 360: 1267-1274, 2002.
5 Molyneux AJ, Kerr RS, Yu LM et Al: International Subarachnoid Aneurysm Trial (ISAT) Collaborative Group: International subarachnoid aneurysm trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms: A randomised comparison of effects on survival, dependency, seizures, rebleeding, subgroups, and aneurysm occlusion. Lancet 366: 809-817, 2005.
6 The CARAT Investigators: Rates of delayed rebleeding from intracranial aneurysms are low after surgical and endovascular treatment. Stroke 37: 1437-1442, 2006.

Shinzo Ota, M.D.
Department of Neurosurgery
Brain Attack Center
Oota Memorial Hospital
3-6-28 Okinogami Fukuyama Hiroshima,
720-0825, Japan
E-mail: tomoko@shouwa.or.jp

Acknowlegrments

We thank Akira Sano, M.D., Kazuhiro Takamatsu, M.D., Michiyoshi Sato, M.D., Akio Tanaka, M.D., Satoshi Kobanawa, M.D., Kazuyuki Tsuchida, M.D., Shiro Chitoku, M.D., Kiyoshi Nakazaki, M.D., Yasue Tanaka, M.D., Shuichi Tanoue, M.D., Junji Kashiwagi, M.D., Ryuichi Shimada, M.D., Kosuke Ota, M.D., and all the staffs of Oota Memorial Hospital. We also thank Akiko Ota, Ph.D., Tamami Matsushita, and Kyoko Taruma of Fukuyama Transporting Shibuya Longevity Health Foundation.